Relationship Between Contaminant Concentrations and Geographic Distribution of Sea Otters in Alaska

Kimberly A. Trust, Linda R. Comerci, Carol S. Gorbics and Angela C. Matz

U.S. Fish and Wildlife Service; Marine Mammals Management and Ecological Services-Environmental Contaminants; USFWS Regions 7 and 1

- **Sea otters and their principle prey (benthic invertebrates) have limited home ranges. Thus, potential contaminant exposure is largely limited to uptake from their local environment. Studying contaminant exposure in sea otters provides an opportunity to examine broad-scale spatial variation in contamination of near-shore habitats.**

- **Tissues were collected for metal/trace element and organochlorine analyses. For statistical comparisons, samples were grouped, by stocks, into three geographic areas.**
- **Overall, sea otters from southcentral Alaska had higher concentrations of environmental contaminants when compared to those animals from either southeast or southwest Alaska.**
- **Persistent organochlorine pesticides and PCBs were not detected or detected at low concentrations in most otters. However, a few individuals from southwest Alaska had elevated concentrations of total PCBs, indicating that PCB contamination may be locally significant.**

INTRODUCTION

Sea otters (*Enhydra lutris*) are found in coastal waters of Alaska from the southeastern part of the state through the Aleutian Islands. Typically, they inhabit protected subtidal and intertidal waters, less than 40 meters deep. Because their primary prey is relatively sedentary, the presence of environmental contaminants in sea otter tissues may reflect contamination of local environments. Moreover, the high trophic status of this mustelid species makes sea otters vulnerable to persistent and bioaccumulating contaminants. Large coastal communities, military installations and geologically active areas may contribute to increased concentrations of contaminants at a local level. Therefore, exposure of sea otters to environmental contaminants may be indicative of contamination throughout the food web of nearshore environments.

Objectives:

- Determine concentrations of metals/trace elements and organochlorines in tissues from sea otters throughout Alaska.
- Compare contaminant concentrations among sea otters from three major geographic areas (southeast, southcentral and southwest).
- Compare contaminant concentrations in Alaska sea otters with literature values from mustelids and marine mammals in other parts of the world.

MATERIALS AND METHODS

Field Collection and Sample Preparation

Sixty-six sea otters were sampled throughout their Alaskan range (Fig. 1) from 1993-1999. Fifty-five subsistence-hunted animals were sampled by Alaska Natives and submitted to the USFWS through the ongoing Sea Otter Biosampling Program. Samples were also collected from eleven whole, beach-cast carcasses.

Livers and kidneys were excised according to standardized collection protocols (Doroff and Mulcahy, 1997). Fifty gram samples were placed into chemically-clean glass jars, frozen and shipped to independent USFWS contract laboratories for chemical analyses.

Laboratory Analyses

Arsenic and selenium residues were determined using graphite furnace atomic absorption spectrometry analysis and mercury residues were determined using cold vapor atomic absorption analysis. All other elemental residues were measured using inductively coupled plasma emission spectroscopy.

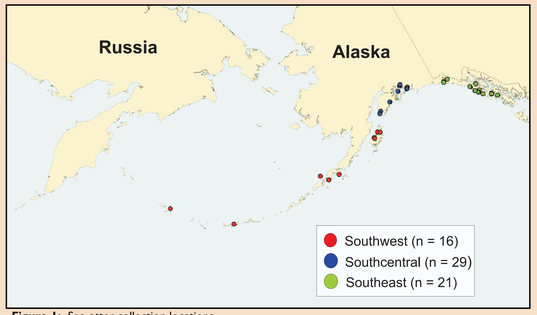

Figure 1: Sea otter collection locations.

Tissue samples were analyzed for organochlorine pesticides and PCBs using either gas or gel chromatography. PCB congeners were confirmed using mass spectroscopy.

Quality assurance/quality control measures were applied to 10% of the samples which were then compared to modified criteria established by Quakenbush and Snyder-Conn (1993) and K. Mueller (USFWS, pers. comm.) for acceptance of analytical data. All analytical data are presented on a dry weight basis.

Statistical Analyses

Based on stock structure (Gorbics and Bodkin, 2001), sea otters were grouped into the following three geographic areas: southeast Alaska, including Yakutat Bay; southcentral Alaska, including Prince William Sound and Cook Inlet; and southwest Alaska, the Alaskan Peninsula through the Aleutian Islands, including the Kodiak Archipelago (Fig. 1).

No statistical tests were performed on those analytes detected in <10% of samples in any group. Non-parametric (univariate Kruskal-Wallis rank sum) tests were used to compare groups in which the specific analyte was detected in >10% and < 90% of samples in each group.

Parametric testing was used to compare groups where analytes were detected in >90% of the samples in each group; here, non-detections were substituted with ½ the detection limit. Data were log-transformed to achieve normality and stabilize variance. When analytes were correlated, principal components analysis (PCA) was used as a method of variable reduction. If PCA cleanly separated the multiple analytes into a few principal components, we used the factor scores to test for differences among groups. If PCA did not cleanly reduce the analytes, we used Multiple Analysis of Variance (MANOVA), retaining all variables with univariate p-values < 0.05, to test for group differences. Significant differences between specific groups in individual analytes were determined with univariate ANOVAs and Bonferroni-adjusted post-hoc comparisons.

RESULTS

Metals

- Al, B, Ba, Be, Cr, Mo and Pb were below detection limits in all samples. Nickel was detected in < 10% of liver samples and < 10% of kidney samples had measurable concentrations of Sr.
- As and V in livers and Ni and V in kidneys were detected in 10-90% of all samples. Arsenic was significantly higher in southcentral sea otter livers when compared to southeast and southwest animals (p<0.05).
- Analytes detected in > 90% of samples included As (kidney only), Cd, Cu, Fe, Hg, Mg, Mn, Se, and Zn. Except for Cu and Mn (kidney only), concentrations of these metals were always higher in tissues from the southcentral group: This trend is demonstrated for livers in Fig. 2.

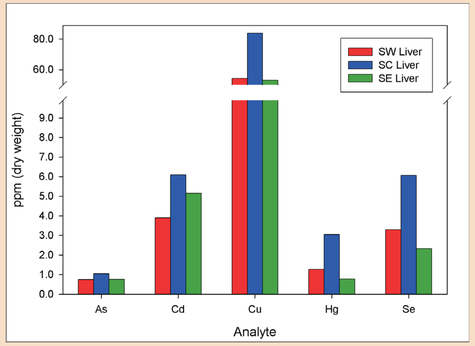

Figure 2: Geometric means of select metal concentrations in livers of Alaskan sea otters

Organochlorine Pesticides

- None of the following compounds were above detection limits (0.01 - 0.05 ppm) in either kidneys or livers: alpha-BHC, alpha-chlordane, delta-BHC, endrin, gamma-BHC, gamma-chlordane, HCB, mirex, o,p'-DDD, o,p'-DDE, o,p'-DDT, and toxaphene. Cis-nonachlor was not detected in kidney samples and was detected in only two liver samples from the southwest group.
- Dieldrin, heptachlor epoxide, p,p'-DDD, and trans-nonachlor were detected in only a few southwest otters thus, were not statistically analyzed for differences among groups.
- Beta-BHC was significantly lower in kidneys from the southcentral group when compared to southeast and southwest (p< 0.05); However, overall concentrations were low (Range = <0.018 - 0.184 ppm dry wght).

Polychlorinated Biphenyls (PCBs)

- Due to inter-annual and inter-laboratory variations in PCB analyses, comparisons among groups were made only for those analytes that were measured consistently and had similar detection limits. Moreover, Aroclors and total PCB concentrations were below detection limits (DL = 0.05 ppm) in some analytical groups. However, congener-specific PCB analyses often yielded actual values, because the detection limits for those analyses were much lower (DL range = 0.001-0.005 ppb).
- In those data sets where Aroclors were measured, Aroclors 1242 and 1248 were not detected in any samples and few detections of Aroclors 1254, 1260, and total PCBs were measured in either livers or kidneys (detection limit = 0.05 ppm dry wght). However, individual otters from certain sites in the Aleutian Islands had elevated concentrations of total PCBs (e.g., 5.6 ppm dry wght) in livers, indicating that these otters may have been directly exposed to local contamination.
- In kidneys, analytes were tested for differences among groups using MANOVA with all analytes as response variables. The final model included PCB Congeners 118, 128, 138, and 153 , but there was no significant multivariate differences among groups (p = 0.178). PCB 138, the only analyte with a univariate p-value < 0.05, appeared lower in southeast compared to the other groups.
- For livers, PCA on those PCB congeners detected in ≥ 90% of the samples clearly separated the data into two principal components, accounting for 89.6% of the variability within the data set.

Using factor scores from the two principal components as response variables, we observed significant multivariate differences among the groups (p = 0.018) in the first PC but not the second. Congeners represented by the first PC, 118, 128, 138, 153, 156, 158, and 170 were higher in the southcentral group compared to southeast and southwest, but significantly higher only compared to southeast. The southwest group was not significantly different from either southcentral or southeast (Fig. 3)

- Overall, PCB congener concentrations were highest in the southcentral group, followed by southwest and southeast.

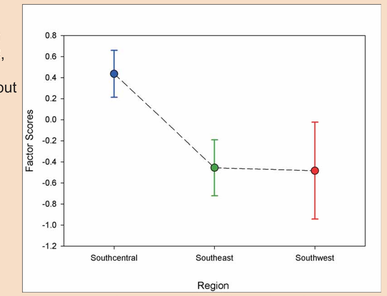

Figure 3: Mean factor scores (± SE) for the first PC comprising select PCB congeners in livers of Alaska sea otters.

DISCUSSION

Metals

Mean metal and trace element concentrations were below toxic thresholds in sea otters sampled throughout Alaska. However, a few individual animals exceeded toxic effects levels for certain elements.

For example, cadmium concentrations in sea otters were not statistically different among geographical areas in Alaska. However, the highest concentrations of cadmium reported in our study were 31 ppm dw (23 ppm ww) in liver and 214 ppm dw (161 ppm ww) in kidney. Comparatively, the highest cadmium concentrations in European otters (*Lutra lutra*) from the Orkney Islands, Scotland, were 0.39 ppm ww in liver and 0.56 ppm ww in kidney (Mason and Reynolds, 1988). Using renal dysfunction as the endpoint, Law (1996) proposed an effects threshold level for cadmium in marine mammals as 20-200 ppm ww in livers and 50-400 ppm ww in kidneys.

Organochlorine Pesticides

Organochlorine pesticides were low in Alaska sea otters. Of all the compounds measured, only beta-BHC was detected in enough samples to analyze by groups: Mean concentrations were lowest in southcentral otters however, the highest concentration in an individual (0.184 ppm dw) was in the liver of an otter from southcentral Alaska.

Variations in contaminant levels in individual animals from the same geographic area may be explained by prey selection. Sea otters have shown individual variations in their specific diet and foraging behavior (Riedman et al., 1995). They mainly feed on benthic invertebrates, however, they are opportunistic and may select fishes if the invertebrate supply is depleted (Kenyon, 1969; Estes et al., 1982). Certain contaminants may bioaccumulate in higher trophic species, thus an otter eating fish may receive a higher contaminant load than one eating invertebrates.

Table 1: Comparison of select PCB congeners in livers from Alaskan sea otters from this study and Bacon et al. (1999) (in parentheses). Data are reported as geometric means; pbb dry weight, and data from Bacon et al. was converted to dry weight using 70% tissue moisture.

PCB Congener	SW	SC	SE	CA
77	0.62	0.178	0.333	n/a
	(0.003)	(n/a)	(0.003)	(0.005)
105	<DL*	0.369	0.217	n/a
	(17.3)	(n/a)	(3.33)	(41.3)
118	<DL*	2.17	1.038	n/a
	(67.7)	(n/a)	(0.33)	(57.3)
126	0.048	0.042	0.041	n/a
	(0.063)	(n/a)	(0.007)	(0.1)
156	<DL*	0.508	0.264	n/a
	(32.3)	(n/a)	(0.667)	(21.7)

* Congener detected in too few samples to calculate mean.

PCBs

Few studies have analyzed sea otter tissues for congener specific PCBs. PCB congeners 126 and 169 were measured in European otters (Leonards *et al.*, 1997), and Bacon et al. (1999) measured congeners in livers from sea otters in the Aleutian Islands, southeast Alaska and California. Table 1 shows comparisons among select PCB congeners between this study and Bacon et al. (1999). Bacon et al. (1999) concluded that congeners 126 and 156 contributed significantly to the overall toxicity of the congener suite measured in their otters. In this study, mean concentrations of 126 were similar to Bacon et al., but mean concentrations of 156 were substantially lower. Moreover, means were not calculated for 156 in the SW group due to insufficient numbers of detections. Therefore, congener toxicity between the two studies was not directly compared.

CONCLUSIONS

Contaminant concentrations in sea otters were generally low throughout Alaska. However, for certain compounds, significant differences in concentrations occurred among groups from three geographic regions. The general pattern of contamination was southcentral > southwest > southeast. Although mean concentrations were usually higher in southcentral sea otters, individual animals from other groups (e.g. otters from Adak Island; SW group) occasionally had elevated concentrations of specific contaminants when compared to other otters within the same group. This seeming anomaly may be explained by differences in sea otter diet among regions or by increased inputs of contaminants at localized sites.

ACKNOWLEDGMENTS

We especially appreciate the many Native subsistence hunters and sample collectors, without whose help this study would not have been possible. We would like to thank Alaska Maritime Refuge and the Alaska Sea Life Center for providing samples and Jordan Stout for sample preparation and poster review. Finally, we would like to thank Douglas Burn for his assistance in preparing this poster, and Dana Seagars and Greg Balogh for their review.

This study was supported by the U.S. Fish and Wildlife Service and the Alaska Sea Otter and Steller Sea Lion Commission. However, the findings and conclusions presented by the authors do not necessarily reflect the views or position of these agencies.

LITERATURE CITED: Available upon request.